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Sir W. BURNETT, M.D., in the Chair.

"On the Automatic Registration of Magnetometers and other Meteorological Instruments, by Photography." By Charles Brooke, M.B., F.R.C.S.E. Communicated by G. B. Airy, Esq., F.R.S., Astronomer Royal.

The author enters into fuller details than he had done in his former communication to the Society, which was read on the 18th of June, respecting the construction of the instrument, the preparation of the highly sensitive photographic paper employed in the process, and the minute adjustments necessary for ensuring accuracy in registering the results.

In a supplement to the above paper, the author describes the methods he has contrived for obtaining a similar automatic registration of the heights of the barometer and thermometer, by suitable additions to the same apparatus which registers the magnetic variations.

November 26, 1846.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

W. R. Grove, Esq., M.A., F.R.S., delivered the Bakerian Lecture —"On certain Phenomena of Voltaic Ignition, and on the Decomposition of Water into its constituent Gases by heat."

The author refers to an eudiometer, an account of which was published by him in the 'Philosophical Magazine' for 1840, formed of a glass tube, into the closed extremity of which a loop of platinum wire was sealed. The gases to be analysed were mixed in this tube with a given volume of oxygen and hydrogen, and detonated or slowly combined by the voltaic ignition of the platinum wire. He was thence led to try a further set of experiments on the analysis, by this instrument, of such gases and vapours as are decomposable

by heat; the process being capable of much greater exactness than the received one of passing them through ignited tubes. The results of the analyses of several gases by this means are given in the paper. When carbonic acid and hydrogen are mixed in equal volumes and exposed to the ignited wire, the hydrogen abstracts oxygen from the carbonic acid, and leaves carbonic oxide. Conversely, when carbonic oxide is exposed over water to the ignited wire, it abstracts oxygen from the aqueous vapour, and forms carbonic acid.

It thus appeared, that provided there were bodies present capable of absorbing by affinity the elements of water, ignited platinum would either compose or decompose water. The author was thence led to hope that he might by ignited platinum decompose water into its constituents, without absorption by other bodies, and thus produce converse effects to those already known. In this he ultimately succeeded by various methods, in some of which the ignition was produced by electrical means; in others by ordinary calorific processes, such as the oxyhydrogen blowpipe, &c.

A platinum wire is ignited at the closed extremity of a species of tube retort, full of pure water, and having a narrowed neck close above the wire; as soon as the wire becomes incandescent, it forms around itself an atmosphere of vapour which it immediately decomposes; a natural valve being formed by the conflict of ascending gas and descending water, the bubbles of mixed gas are cut off by an intermittent action, and thus, as their recombination is prevented, a volume of gas collects in the bend of the tube and is ultimately expelled at its orifice. If, again, a button of platinum be fully ignited by the oxyhydrogen blowpipe, and plunged into water previously heated to nearly its boiling-point, bubbles of mixed gas ascend and may be collected by an inverted tube. The electrical spark is shown to be capable of decomposing aqueous vapour, and various other modes of producing the same results are given.

Some theoretical views are then advanced as to the spheroidal state which appears to the author to be intermediate between that of ebullition and decomposition; as to the probable non-existence of water or steam in the interior of the earth, and as to the antagonism between physical repulsion and chemical affinity.

In a supplementary paper, the author considers how far catalysis affects the phenomenon, and regards the decomposition thus produced as presenting a parallel effect produced by the force of heat, to that known to be produced by electricity; he considers it explanatory of the decomposition of water by the electrical spark as in the experiments of Pearson and Wollaston. Some further experiments are given, in which iridium and osmium and silica are substituted for platinum; and also some experiments on the liquids bromine and chloride of iodine, both of which yield pure oxygen when exposed to the ignited wire in Mr. Grove's apparatus. These last experiments cannot however be long continued in consequence of these liquids ultimately attacking both the glass and the platinum. In conclusion, the author calls attention to the general evolution of

permanent gas from all liquids, except the metals, when exposed to intense heat.

December 17, 1846.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

"Researches on Physical Geology."—Part I. The Figure and Primitive Formation of the Earth. By Henry Hennessy, Esq. Communicated by Major North Ludlow Beamish, K.H., F.R.S.

The author's investigations of the figure of the earth proceed on the hypothesis of its having originally been a heterogeneous fluid mass, possessing only such general properties as those which have been established for fluids; and independently of the supposition, with which the theory has generally been complicated, that the volume of the entire mass, and the law of the density of the fluid, have suffered no change in consequence of the solidification of a part of that fluid. Assuming the figure of the mass to be an ellipsoid of revolution, the author obtains general analytical expressions for its ellipticity, and for the variation of gravity at its surface. He gives a general sketch of the consequences that may result from the improved hypothesis of the primitive figure of the earth, to physical geology, that is, to the changes occurring upon the external crust of the earth during the process of its solidification, resulting both from calorific and chemical changes taking place among its different parts, and giving rise to a process of circulation throughout the fluid portions of the mass.

The present memoir is only the first of a series which the author announces it is his intention to communicate to the Society on the same subject.

January 7, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Sir George Back, Capt. R.N., was elected into the Society.

The following paper was read:—

"Quelques Recherches sur l'Arc Voltaique; et sur l'influence qu'exerce le Magnétisme, soit sur cet Arc, soit sur les Corps qui transmettent les Courants Electriques Discontinus." By M. Auguste De la Rive, Foreign Member of the Royal Society, Professor in the Academy of Geneva, Corresponding Member of the Academy of Sciences of Paris, &c.

In the first section of this memoir the author gives a detailed description of the phenomena exhibited by the luminous voltaic arc produced either in a vacuum or in atmospheric air, or in hydrogen gas, by employing electrodes of different kinds of conducting sub-

stances, in the form either of points or of plates. He examines minutely the transfer of particles which takes place from one pole to the other under these various circumstances, and the differences which occur when the currents are reversed. He observed that when a positive metallic point is presented to a negative plate, particles of the former are transported by the voltaic arc, and deposited on the latter, forming a ring of a regular form, having as its centre the projection of the point on the plate. This happens in atmospheric air whether highly rarified or of the ordinary density, but not in hydrogen gas. This deposit consists always of oxidized particles of the positive metal which forms the pointed electrode. In the case of platinum, the circular spot is of a blue colour, and presents the appearance of the coloured rings of Nobili. This effect the author is disposed to ascribe to the action of the oxygen brought by the voltaic current into that particular condition which Schœnbein first described under the name of *Ozone*. While this deposit is taking place, a vivid blue light is emitted.

In the second section the author investigates the action exerted by a powerful electro-magnet on the voltaic arc. He describes the remarkable modifications which the length, the form, and even the nature of the arc undergoes when the electro-magnet is brought extremely near to it, and the magnetization of the electrodes themselves, when they are susceptible of that affection by their approximation to the electro-magnet. He notices the singular phenomenon of a peculiar sound emitted by the luminous arc, when subjected to this magnetic influence; a sound which varies both in its nature and its intensity according to the nature, the form and the temperature of the electrodes, consisting sometimes of a shrill whistle, and at other times of a series of slight detonations.

The third section is devoted to the investigation of a remarkable phenomenon presented by all the conducting bodies while transmitting discontinuous electric currents, under the influence of a powerful electro-magnet; namely, the emission of a sound resembling that of the revolving toothed-wheel in Savart's experiments. This sound is distinctly heard, and is peculiarly loud with prismatic bars of lead, bismuth, tin, &c., about three-quarters of an inch square and a foot and a half long, whether placed in the direction of a line joining the poles of an electro-magnet, or in a direction at right angles to such line: it was weakened only by increasing the distance between the poles and the bar. The intensity of the sound appeared to depend much less on the nature of the substance which was subjected to this action, than on its form, its volume, and its mass. All conducting bodies, whatever may be their nature, or state of aggregation, are capable of yielding these sounds. They are produced by charcoal of all kinds and shape. Mercury contained in a cylindrical glass tube, of similar dimensions with the metallic bars, emits a sound of great intensity; and a still louder sound arises from a wire coiled as a helix around a cylinder of wood, and also by tubes formed of different metals. Similar phenomena are also observable by the action of a helical coil substituted for the electro-magnet.

On the whole, the author arrives at the conclusion that the phenomena noticed in this paper are altogether molecular, and that they establish the following principles: first, that the passage of the electric current modifies, even in solid bodies, the arrangement of the particles; and secondly, that the action of magnetism, in like manner, produces an analogous modification in the molecular constitution of all bodies. This has already been demonstrated by Faraday in the case of transparent bodies, in its effects on polarized light; and is now extended by M. De la Rive to opaque conducting bodies, by employing, instead of polarized light, a discontinuous electric current.

"On the Ganglia and Nerves of the Virgin Uterus." By Robert Lee, M.D., F.R.S., &c.

The author states that his recent dissections have enabled him to verify the descriptions he gave of the ganglia and nerves of the uterus in his papers already published in the Philosophical Transactions, and also to detect the existence of ganglia situated in the muscular coat of the uterus, and of plexuses of nerves accompanying all the blood-vessels and absorbents ramifying in its walls, between the peritoneum and lining membrane. By examining the hearts of a fœtus, of a child of six years of age, of an adult in the sound state, a human heart greatly hypertrophied, and the heart of an ox, he found that there exists a striking analogy between the ganglia and nerves of the uterus and those of the heart. He ascertained by microscopic observation that the muscular and vascular structures of the auricles and ventricles are endowed with numerous ganglia and plexuses of nerves, which, as far as he knows, have not yet been described, and which enlarge simultaneously with the natural growth of the heart, and also continue to enlarge during its morbid conditions of hypertrophy. The author also finds that the size of the ganglia and nerves of the left auricle and ventricle, in the normal state, is more than double that of the corresponding parts on the right side. A description is then given of two elaborate drawings which accompany the paper.

"On a new and practical form of Voltaic Battery of the highest powers, in which Potassium forms the positive element." By John Goodman, Esq. Communicated by S. Hunter Christie, Esq., A.M., Sec. R.S.

The author succeeded in constructing a voltaic arrangement of some power by fixing a piece of potassium to the end of a copper wire, placed in a tube containing naphtha, and bringing it in contact with a small quantity of mercury, held by a layer of bladder closing the lower end of the tube, which was itself immersed in acidulated water immediately over a piece of platinum, and then completing the circuit by establishing a metallic contact between the copper wire and the platinum. This battery acted with energy on the galvanometer, and effected the decomposition of water. A series of twelve pairs of similar plates exhibited a sensible attraction

of a slip of gold leaf. Thus it appears that the substance which possesses the highest chemical affinity manifests also the greatest power of electrical tension.

January 21, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Henry Dyke Acland, M.D. was elected a Fellow of the Society.

"On Photographic Self-registering Meteorological and Magnetical Instruments." By Francis Ronalds, Esq., F.R.S., &c.

The apparatus employed by the author at the Kew Observatory, and which he terms the Photo-Electrograph, is described by him in the following words:—"A rectangular box, about sixteen inches long and three square, constitutes the part usually called the *body* of a kind of lucernal microscope. A voltaic electrometer (properly insulated, and in communication with an atmospheric conductor) is suspended within the microscope, through an aperture in the upper side, and near to the *object* end. That end itself is closed by a plane of glass, when daylight is used, and by condensing lenses, when a common Argand lamp is employed. In either case an abundance of light is thrown into the microscope. Between the electrometer and the ether, or eye-end of the microscope, fine achromatic lenses are placed, which have the double effect of condensing the light upon a little screen, situated at that eye-end, and of projecting a strong image of the electrometer, in deep *oscuro*, upon it. Through the screen a very narrow slit, of proper curvature, is cut (the chord of the arc being in a horizontal position), and it is fitted into the back of a case, about two-and-a-half feet long, which case is fixed to the eye-end of the microscope, at right angles with its axis, and vertically. Within the case is suspended a frame, provided with a rabbet, into which two plates of pure thin glass can be dropped, and brought into close contact by means of six little bolts and nuts. This frame can be removed at pleasure from a line, by which it is suspended, and the line, after passing through a small aperture (stopped with grease) cut through the upper end of the long case, is attached to a pulley (about four inches in diameter), fixed, with capacity of adjustment, on the hour arbor of a good clock. Lastly, counterpoises, rollers, springs, and a straight ruler are employed for ensuring accurate rectilineal sliding of the frame, when the clock is set in motion.

"A piece of properly prepared photographic paper is now placed between the two plates of glass in the moveable frame; the frame is removed (in a box made purposely for excluding light), and is suspended in the long case; this is closed, so as to prevent the possibility of extraneous light entering with it; the clock is started, and the time of starting is noted.

"All that part of the paper which is made to pass over the slit in the screen, by the motion of the clock, becomes now therefore successively exposed to a strong light, and is consequently brought into a state which fits it to receive a dark colour on being again washed with the usual solution, excepting those small portions upon which dark images of the lower parts of the pendulums of the electrometer are projected through the slit. These small portions of course retain the light colour of the paper; and from the long curved lines or bands, whose distances form each other, at any given part of the photograph, i. e. at any given time indicate the electric tension of the atmosphere at that time.

"By certain additions to the instrument above described, the kind as well as the tension of electrical charge is capable of being registered; and by the employment also of a horizontal thermometer, &c., it is adapted to the purposes of a *Thermograph*, as well as *Photo-barometrograph* and *Magnetograph*."

January 28, 1847.

LEONARD HORNER, Esq., Vice-President, in the Chair.

"On the Lunar Atmospheric Tide at St. Helena." By Lieut.-Colonel Edward Sabine, R.A., For. Sec. R.S.

The results of the observations made by Captain Lefroy, of the Royal Artillery, Director of the Magnetical and Meteorological Observatory at St. Helena, are here given; from which it appears, on the examination of the barometrical changes during seventeen months, that a maximum of pressure corresponds to the moon's passage over both the inferior and superior meridians, being slightly greater in the latter case, and that a minimum corresponds nearly to the rising and setting, or to six hours before and after the former periods. The average atmospheric pressures are 28·2714 inches in the first case, and 28·2675 in the last; the difference being 0·0039 inch. The height of the cistern of the barometer above the sea is 1764 feet; and the latitude of the Observatory 15° 57′ S. These results were still further confirmed by those of a series of observations during two years. These observations also establish the conclusion that the moon exerts a greater influence on the amount of atmospheric pressure at the periods of her perigee than at those of her apogee.

February 11, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

The following paper was read:—

"On the Amount of the Radiation of Heat, at night, from the

Earth, and from various Bodies placed on, or near the surface of the Earth." By James Glaisher, Esq. Communicated by G. B. Airy, Esq., F.R.S., Astronomer Royal, &c.

The author enters into a very detailed description of the construction of the thermometers he employed in these observations, and the precautions he took to ensure their accuracy; and gives tabular records of an extensive series of observations, amounting to a number considerably above ten thousand, with thermometers placed on nearly a hundred different substances, exposed to the open air, under different circumstances, and in various states of the sky, at the Royal Observatory at Greenwich.

February 18, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Edward John Rudge, Esq., was elected a Fellow of the Society.

"On the Diurnal Variation of the Magnetic Declination of St. Helena." By Lieut.-Colonel Edward Sabine, R.A., For. Sec. R.S.

It has long been known that the diurnal variation of the magnetic needle is in an opposite direction in the southern, to what it is in the northern hemisphere; and it was therefore proposed as a problem by Arago, Humboldt and others, to determine whether there exists any intermediate line of stations on the earth where those diurnal variations disappear. The results recorded in the present paper are founded on observations made at St. Helena during the five consecutive years, from 1841 to 1845 inclusive; and also on similar observations made at Singapore, in the years 1841 and 1842; and show that at these stations, which are intermediate between the northern and southern magnetic hemispheres, the diurnal variations still take place; but those peculiar to each hemisphere prevail at opposite seasons of the year, apparently in accordance with the position of the sun with relation to the earth's equator.

February 25, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

The Earl of Hardwicke was elected a Fellow of the Society.

Rev. J. O. W. Haweis, M.A., was put to the ballot, but not elected.

"On certain Properties of Prime Numbers." By the Right Hon. Sir Frederick Pollock, M.A., F.R.S., Lord Chief Baron of the Exchequer, &c.

The author of this paper, after noticing Wilson's Theorem, (published by Waring about the year 1770, without any proof), which theorem is that, if A be a prime number, $1.2.3.\ldots(A-1)+1$ is divisible by A; refers to Lagrange's and Euler's demonstrations, and mentions Gauss's extension of the theorem, to any number, not prime; provided that instead of 1, 2, 3, &c. (A−1), those numbers only be taken which are prime to A, and 1 be either added or subtracted. This theorem was published by Gauss without a proof in 1801, with a rule as to the cases in which 1 is to be added or subtracted, the correctness of which is questioned by the author, who proceeds to propound the following theorem, which he had previously, for distinctness, divided into three.

If any number, prime or not, be taken, and the numbers prime to it, and less than one half of it be ascertained, and those be rejected whose squares ± 1 are equal to the prime number, or some multiple of it (which may be more than one), then the product of the remaining primes (if any), ± 1 shall be divisible by the prime number.

He gives as examples, 14, the primes to which, and less than one half, are 1, 3, 5, and $1.3.5=15$; therefore $1.3.5-1=14$; also 15, the primes to which and less, are 1, 2, 4, 7; but $4\times4=16=15+1$; therefore 4 is to be rejected, and $1.2.7+1=15$. The author adds another theorem, that if A be a prime number, all the odd numbers less than it (rejecting as before); also, all the even numbers (making the same rejection except A−1) will, multiplied together, be equal to $A\pm1$.

The author then proceeds to prove Gauss's extension of Wilson's theorem, and to give the cases in which 1 is to be added or subtracted; and in the course of the proof, he mentions that the numbers prime to any number not only are found in pairs, one greater and one less than one-half of the number, but that they associate themselves in sets of four, with an odd pair in certain cases. Thus, the primes to 7 are 1, 2, 3, 4, 5, 6,—

$$2\times4=8=7+1.$$

Put the complemental numbers underneath crosswise, thus,—

$$\begin{array}{ccccc} 2 & \times & 4 & & \\ & \diagdown & \diagup & & \\ & & \times & & \\ & \diagup & \diagdown & & \\ 3 & \times & 5 & & \end{array}$$

so that $2+5$ and $4+3$ may equal 7; and then

$$3\times5=15=2\times7+1$$
$$2\times3=6=7-1 \qquad\qquad 4\times5=20=3\times7-1$$

Multiplied together one way the product exceeds 7, or a multiple of it, by 1; multiplied the other way, the product is less than 7, or some multiple of it, by 1. By assuming the prime number to be A, and the two primes to it to be p, q, and that $p+q$ be not equal to A, but $pq=n\mathrm{A}\pm1$, it is shown that the complemental primes

$(A-q)$ and $(A-p)$ will have a product$=n'A\pm1$, and that, instead of 1, the number may be any other prime to A. Upon this foundation the author proceeds to show that Wilson's theorem, and also Gauss's, may be made much more general; that if A be a prime number, as 7, the numbers less than it may be arranged in pairs, not only with reference to 1, but to any number less than 7. Take 4 as an example:—

$$1 \times 3=7-4$$

$$4 \times 6=4\times7-4$$

$$2 \times 5=2\times7-4$$

therefore $1.2.3.4.5.6=7n-4^3$;
therefore $1.2.3.4.5.6+4^3=7n$; that is, is divisible by 7.

The same is then shown as to numbers not prime, provided those numbers alone are taken which are prime to it, and the number of pairs will be half the number of primes. The general theorem therefore is this:—If A be any number, prime or not, and m be the number of primes to it, which are $1, p, q, r$, &c.; then $1.p.q.r$, &c., $\pm Z^{\frac{m}{2}}$ will be divisible by A, provided Z be prime to A, whether it be greater or less.

It follows from this that $z^{\frac{m}{2}}+1$ must be divisible by A, and therefore that z^m-1 must be divisible by A. If A be a prime number and z a number prime to it (which every number not divisible by it is), this is Fermat's theorem, and the author has given a new proof of it. But the theorem is true though A be not a prime number, provided z be prime to A and m be the number of primes to A, and less than it; and instead of 1, any other number prime to A raised to the mth power may be substituted: and z^m-y^m will be divisible by A, provided z and y be primes to A, and m be the number of primes to A and less than it.

The author has therefore in this paper offered a proof of Gauss's theorem, and proved that it applies in certain cases to one half of the primes, and in all cases, with certain modifications, has shown that a similar property belongs to the product of the odd numbers, and also of the even numbers which precede any prime number; and lastly, has shown the intimate connexion between Wilson's theorem and Fermat's, and shown that each is but a part of a much more general proposition, which, he observes, may itself turn out to be part only of a still more universal one.

In a postscript, the author has shown that the well-known law of reciprocity of prime numbers is an immediate corollary from his theorem; and that it may be extended thus: if A and B be any two numbers (not prime numbers but) prime to each other, and the primes to A, and less than it, are (m) in number, and the similar primes to B are (n), then (A^n-1) is divisible by B, and (B^m-1) is divisible by A.

"On the reabsorption of the Mixed Gases in a Voltameter." By Professor M. H. Jacobi, in a letter to Michael Faraday, Esq., F.R.S. Communicated by Dr. Faraday.

The author found that if the mixed gases developed from the decomposition of water by a voltaic current, be allowed to remain in the voltameter in which they were collected, in contact with the fluid which produced them, they by degrees diminish in volume, and ultimately disappear by being absorbed by the fluid. He has not yet fully determined the precise conditions on which this phenomenon depends; but he is inclined to think that it is owing to a portion of the mixed gases, diffused throughout the whole liquid, coming into contact with the platinum plates, and being recombined on the surface of those plates; and this process being renewed with every fresh portion of the gases which takes the place of the former, the whole of the gases are thus reconverted into water.

March 4, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

Charles Brooke, Esq. was elected a Fellow of the Society.

"Researches into the effects of certain Physical and Chemical Agents on the Nervous System." By Marshall Hall, M.D., F.R.S., &c.

The professed object of the author, in the present paper, is "to detail the results of an investigation of the phenomena and the laws of production and action of certain secondary or induced conditions of the nervous system, which are effected by a voltaic, and probably by any other electric current, but persistent after the influence of that current is withdrawn." This condition he designates by the new term *electrogenic*, as describing at once the origin and the independence of that condition. On the present occasion he confines himself to the subject of the electrogenic condition of the muscular nerves, postponing to future inquiries that of the incident nerves and of the spinal marrow; and also the modes of action of other physical and chemical agents, such as mechanical injury, heat and cold, strychnine, and the hydrocyanic acid.

The bones and muscles of the brachial lumbar and pelvic regions of a frog, being isolated from all the other parts of the body, excepting only by means of their respective brachial and lumbar nerves, which were perfectly denuded on all sides, and raised from the glass on which the limbs were laid, a voltaic current from a pair of the "couronne de tasses" was passed downwards through the nerves, in a direction from their origin in the spinal marrow towards their terminations in the muscles. Energetic muscular movements were at first excited; and the current was thus continued during the space of five, ten, or fifteen minutes, and at the end of this period was

withdrawn. No sooner was the current discontinued than the muscles were affected with spasmodic contractions, and with a tetanoid rigidity, constituting the secondary, or what the author denominates the *electrogenic condition*; an effect, which as instantly subsides on the restoration of the voltaic current.

The author proceeds to state the precautions which must be taken to ensure the success of experiments on this subject; and traces the effects of desiccation of the nerves from spontaneous evaporation, and of the application of external moisture, on the phenomena; and also the modifications introduced by varying the extent of voltaic contact. Various experiments are then described, which the author instituted with a view to ascertain the nature of the electrogenic condition of the nerves, and the circumstances under which it is induced; and he is led to the conclusion that the phenomena involve some voltaic principle which has not hitherto been fully investigated.

March 11, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

"On the cause of the discrepancies observed by Mr. Baily with the Cavendish Apparatus for determining the Mean Density of the Earth." By George Whitehurst Hearn, Esq., of the Royal Military College, Sandhurst. Communicated by Sir John F. W. Herschel, Bart., F.R.S.

After taking a summary review of the methods employed by Mr. Baily for determining, on the plan devised by Mr. Cavendish, the mean density of the earth, and of the anomalies, hitherto unaccounted for, which had introduced perplexity in the results obtained, the author, suspecting that these anomalies had their source in the variable magnetic states of the masses which were the subject of experiment, traces the effects which such an influence might be supposed to have on those results. He finds that, the attraction arising from gravitation between a mass and one of the balls being exceedingly minute, an almost inconceivably feeble magnetic state may be the cause of great perturbations. He then proceeds to investigate the subject by the application of mathematical analysis; from which he is led to the conclusion that the masses and balls do actually exert on one another influences which are independent of the action of gravitation. He finds that such influences are of a very fluctuating nature; the action arising from them being either positive or negative, and its sign also changing in each revolution as the masses are turned round a vertical axis; and he observes that such action may either fall short of that arising from gravitation or exceed it many times. Such disturbing force he conceives can be no other than a magnetic influence; not however one of the ordinary kind, but that which Faraday has recently discovered as affecting all diamagnetic bodies.

The author concludes by proposing methods by which the inquiry should in future be conducted, so as to obviate or eliminate this source of error. Such an inquiry, he remarks, would, by exhibiting the magnetic and diamagnetic powers under new aspects, lead, in all probability, to important consequences.

March 18, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

J. R. Christie, Esq. and Thomas Webster, Esq. were elected into the Society.

"Researches to determine the Number of Species and the Mode of Development of the British Triton." By J. Higginbottom, Esq., F.R.C.S. Communicated by Thomas Bell, Esq., F.R.S.

The observations of the author, of which he gives a detailed account in the present memoir, have led him to the following conclusions:—

Two species only of the genus Triton are met with in England; namely, the *Triton verrucosus* and the *Lisso-triton punctatus*. It is three years before the animal is capable of propagating its species, and four years before it attains its full growth. In its tadpole state, it remains in the water till its legs acquire sufficient strength to qualify it for progressive motion on land. While a land animal, it is in an active state during the summer, and passes the winter in a state of hybernation; but does not then, as has been erroneously supposed, remain at the bottom of pools. Very dry, or very wet situations are incompatible with the preservation of life during the period of hybernation. At the expiration of the third year, the triton revisits the water, in the spring season, for the purposes of reproduction, and again leaves it at the commencement of autumn. Impregnation is accomplished through the medium of water, and not by actual contact. The growth and development of the triton are materially influenced by temperature, and but little by the action of light. The triton possesses the power of reproducing its lost limbs, provided the temperature be within the limits of 58° and 75° Fahrenheit; but at lower temperatures, and during the winter, it has no such power.

April 15, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

William Baly, M.D., Thomas Flower Ellis, Esq., John Gorham Maitland, Esq., and W. H. C. Plowden, Esq. were elected into the Society.

"On the Proper Motion of the Solar System." By Thomas Galloway, Esq., A.M., F.R.S.

The object of this paper is to communicate the results of a calculation for determining the direction of the proper motion of the solar system from the apparent proper motions of stars in the southern hemisphere, deduced mostly from a comparison of the observations made by Lacaille at the Cape, about the middle of the last century, with the recent observations of Mr. Johnson and the late Professor Henderson at St. Helena and the Cape respectively. After adverting to the papers of Sir William Herschel in the Philosophical Transactions for 1783 and 1805, and some other investigations of the same subject, the author remarks that up to a recent period astronomers seem generally to have entertained the opinion that our knowledge of the proper motions of the stars is not sufficiently advanced to enable us to pronounce positively either on the fact or the direction of the motion of our own system. This opinion was grounded on the discrepancies which present themselves when it is attempted to explain the observed displacements of individual stars by referring them to the motion of the sun in an opposite direction; it being always found that whatever direction is assigned to the sun's motion, there are many stars whose proper motions cannot thereby be accounted for. But if the sun be in motion it is very improbable that any star is absolutely at rest; hence the proper motions deduced from a comparison of catalogues must be regarded as the effect partly of the true proper motions of the stars, and partly of the apparent systematic or parallactic motion caused by the displacement of the point of view; and as we have no reason for supposing the true proper motion of a star to be more probable in one direction than in another, it may be expected, *à priori*, that the observed directions will form angles of all different values with the direction of the sun's motion, or any other fixed line. The observed discrepancies are therefore not incompatible with a general drifting of the stars towards a particular region of the heavens; but in order to deduce the direction of the systematic motion, it becomes necessary to take account of a very considerable number of proper motions, and to represent them by equations, involving the unknown quantities required for determining the direction of the sun's motion, and to solve the equations so as to obtain the most probable values of those quantities. The first person who investigated the subject under this point of view was Professor Argelander of Bonn, in a paper published in the Petersburg Memoirs for 1837. From the proper motions of 390 stars deduced from a comparison of Bessel's catalogue of Bradley's observations with his own catalogue of stars observed at Abo, Argelander found the direction of the sun's motion, for 1792·5, to be towards the point of the sphere whose right ascension is 259° 47′·6 and declination +32° 29′·5. Lundahl, subsequently, from a comparison of the places of 147 stars in the catalogues of Bessel and Pond, and not included among those considered by Argelander, found the co-ordinates of the point to be $R = 252° 24'·4$, Dec. $+14° 26'·1$; and Otto Struve,

still more recently, from the comparison of about 400 of Bradley's stars with the positions determined at the Dorpat Observatory, obtained the result $\mathcal{R}=261^\circ\ 23'{\cdot}1$, Dec.$+37^\circ\ 35'{\cdot}7$. The mean of those results taken with respect to their probable errors, was found by O. Struve to be $\mathcal{R}=259^\circ\ 9'{\cdot}4$, Dec.$+34^\circ\ 36'{\cdot}5$.

All the stars included in the calculations of Argelander, Lundahl, and O. Struve being situated to the north of the tropic of Capricorn, it appeared to be a point of some interest to determine whether the southern stars agree with the northern in their indication of the direction of the solar motion, or afford any confirmation of the hypothesis of the sun's translation. Unfortunately, we have no observations made in the southern hemisphere in the last century equal in precision to those of Bradley, but the catalogue given by Lacaille in his 'Astronomiæ Fundamenta,' furnishes a means of comparison of considerable value in reference to the present inquiry. In Mr. Johnson's 'Catalogue of 606 Stars in the Southern Hemisphere' (London, 1835), there are sixty-one which, on comparing their places in 1830 with those of Lacaille reduced to the same epoch, appear to have shifted their positions not less than 8″ in space in the interval of eighty years between the epochs of the catalogues, or to have an annual proper motion of not less than one-tenth of a second in space. Prof. Henderson's catalogue (Mem. R. Astron. Society, vols. x. and xv.) furnishes thirty-six stars, which, on a like comparison, appear to have an annual proper motion exceeding the same limit. Of these, however, thirty-two are contained in Mr. Johnson's catalogue, but Henderson gives the proper motions of sixteen other stars (in the southern hemisphere), from the comparison of his own places with those of Bradley. On the whole, therefore, the two catalogues furnish eighty-one different stars whose proper motions are given both in right ascension and declination. The method of investigation is the same as that of Argelander. From the differences of $\mathcal{R}$ and Dec. given by comparison of the catalogues, the direction of the *apparent* motion of each star is computed. It is then assumed that the sun is moving towards a point whose right ascension $A=259^\circ\ 46'{\cdot}2$ and declination $D=+32^\circ\ 29'{\cdot}6$; and the direction in which each star would appear to move, if it were itself at rest, is computed on this hypothesis. The difference of these two directions is treated as an error of observation, and its numerical value substituted for the differential of the angle which determines the direction of the parallactic motion; this differential being expressed by a formula containing the differentials of A and D multiplied by known coefficients. An equation is thus obtained of the form

$$0=ad\mathrm{A}+bd\mathrm{D}+n,$$

in which a, b, and n are known quantities. Each star furnishes a similar equation; and the equations, being first multiplied respectively by the sine of the star's distance from the point assumed as the apex of the sun's motion, in order to give them all the same weight, are solved by the method of least squares, and the result-

ing values of dA and dD applied as corrections to the assumed values of A and D. The results are as follows:—the whole of the eighty-one equations give (for 1790) as co-ordinates of the point towards which the sun's motion is directed,

$$\text{R}=263^\circ\ 38'{\cdot}0\pm5^\circ\ 14'{\cdot}5\,;\ \text{Dec.}=+37^\circ\ 15'{\cdot}0\pm6^\circ\ 17'{\cdot}6.$$

But two of the stars compared with Lacaille move in a direction so nearly opposite to that of their motion on the assumed hypothesis, that (in one case especially) a slight error of observation would change the sign of n in the equations of condition. It therefore appears necessary to reject those two stars; and a further reason for rejecting them is, that they are both situated within 8° of the pole, in which position Lacaille's determination of the right ascension is probably not to be depended upon. Setting aside, therefore, the two stars in question, the remaining seventy-nine equations give

$$\text{R}=256^\circ\ 51'{\cdot}5\pm4^\circ\ 45'{\cdot}1\,;\ \text{Dec.}=+34^\circ\ 14'{\cdot}3\pm5^\circ\ 36'{\cdot}2.$$

The author further observes, that one of the stars compared with Bradley's catalogue is also remarkable as appearing to move in a direction nearly opposite to the mean direction of the whole, and that if this star be rejected also on account of the great probability there is that the parallactic motion is in this case concealed by the larger proper motion of the star itself in an opposite direction, the co-ordinates of the solar apex become

$$\text{R}=259^\circ\ 47'{\cdot}4\pm4^\circ\ 31'{\cdot}9\,;\ \text{Dec.}=+34^\circ\ 19'{\cdot}5\pm5^\circ\ 17'{\cdot}7,$$

a result differing less than a degree either in right ascension or declination from the mean, as above stated, of the three previous determinations.

April 22, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

The Earl of Mountcashel, Henry Alexander, Esq., George Burrows, M.D., Sir Fortunatus Dwarris, William Hutchison Hall, Esq., Capt. R.N., Joseph Dalton Hooker, M.D., John Percy, M.D., and Sir Francis Simpkinson, Q.C. were elected Fellows of the Society.

John Farey, Esq. and George Smith, Esq. were put to the ballot but not elected.

"On a new substance occurring in the Urine of a Patient with Mollities Ossium." By Henry Bence Jones, M.D., F.R.S., Physician to St. George's Hospital.

The chemical analysis of this substance showed it to be the hydrated deutoxide of albumen, of which 66·97 parts were contained in every 1000 parts of urine, an amount equal to the proportion of albumen in healthy blood; so that every ounce of urine secreted was equivalent to the loss of an equal quantity of blood. The peculiar characteristic of this substance was its solubility in water, and its being precipitated by nitric acid; the precipitate being dissolved by heat, and again thrown down by cold. The urine which contained it was reddened by the addition of nitric acid; a phenomenon, the occurrence of which might, in future cases, lead to its re-discovery.

A letter was read from William A. Norton, Esq., addressed to the President and Fellows of the Royal Society, and communicated by Lieut.-Colonel Sabine, R.A., For. Sec. R.S., containing the notice of some results which the author states he has obtained from a mathematical investigation founded on a new theory of Terrestrial Magnetism, and which he intends, at an early period, to communicate to the Society.

April 29, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

"On Carbonic Acid as a Solvent in the process of Vegetation." By John Davy, M.D., F.R.S.

In this paper the author describes the results of experiments made with water saturated with carbonic acid, in many instances condensed by pressure and supersaturated, on the more important inorganic elements of plants, compounds not soluble in water alone, such as phosphate of lime, silica, &c. These results appear to prove that this acid performs in the economy of growing plants a double function; one well-known, already carefully studied, by which, undergoing decomposition in the leaves under the influence of solar light, it supplies carbon to the growing vegetable, and restores oxy-

gen to the atmosphere; the other, hitherto little attended to, in which it acts as a menstruum, conveying certain compounds, insoluble in water, from the soil into the interior of plants to become constituents of their organism.

The experiments he details are of two kinds, one set being on single compounds, the other on a mixture of these compounds. The results of the latter seem to prove that water impregnated with carbonic acid is capable of dissolving several substances at the same time, and of keeping them mixed in solution, as carbonate of lime, carbonate of magnesia, phosphate of lime, silica, &c.

He concludes his paper with certain remarks of a theoretical nature, founded on his experimental results, bearing on vegetable physiology, soils and their substrata, and mineral waters,—making these remarks, as he says, with the hope of drawing attention to the subject in its most interesting relations, and of exciting further and more minute research.

"An Account of the Hurricane of the 10th of October, 1846, at the Havanna, contained in a Despatch addressed to Viscount Palmerston by Her Majesty's Commissioners at the Havanna, dated the 24th of February, 1847." Communicated, through the President, by Viscount Palmerston.

The hurricane commenced at half-past ten o'clock on the night of the 10th of October, 1846, and was at its utmost height until from seven to ten the following morning, producing the most extensive destruction of houses and public buildings, and great devastation among the shipping in the harbour. The barometer was observed to fall to the lowest point, after the hurricane had subsided. The progress of the hurricane appears to have been from the south, and passing on to the west, to have lost itself in Florida. It was not attended with lightning, as was the case with the hurricane of 1844.

May 6, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

The Right Hon. Lord John Russell was elected into the Society.

"Researches into the effects of certain Physical and Chemical Agents on the Nervous System." By Marshall Hall, M.D., F.R.S., &c.

In this paper, to which the author considers his former communication as strictly preliminary, he proposes to treat of what he terms the electrogenic state in the spinal marrow and in incident nerves, and to give the details of the collateral experiments he alluded to at the close of his last paper. He also submits to the consideration of the Society the following circumstances, namely,

"1. The electrogenic state of the nerves admits of being dis-

charged, and is capable of inducing the phenomena of voltaism in other nerves.

"2. This state is inducible by momentary and slight voltaic currents.

"3. It is more inducible by the reverse than by the direct voltaic current, as stated by others.

"4. When a nerve forms a part of the voltaic circle, new and superadded circles may be effected, which, by inducing a *change* in the condition of the first, result in the phenomena of muscular contractions.

"5. When the voltaic circle is either complete, or, being completed, is broken, and various parts of the wires and animal tissues which form or formed that circle are *connected* by a conductor, a series of phenomena is produced, some of which still require explanation.

"6. It is also important, especially in a medical point of view, to observe the manner and degree in which the *vis nervosa* and the *vis muscularis* are diminished by repeated voltaic action."

In conclusion the author observes, "I have purposely and carefully avoided all theoretical views, confining myself to the accurate detail of experiments. The condition induced in the nervous system by a current of voltaism I have denominated the *electrogenic*. It might be viewed as one of polarization, its discharge one of depolarization. But I have nothing to add to these views, beyond what is universally known. The phenomena of the continuous, interrupted, and sudden discharge of the electrogenic condition, have not, I believe, been traced and detailed before."

May 20, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

A paper was read, entitled "On the Nervous System of the Heart." By Robert Lee, M.D., F.R.S.

The author premises a historical notice of the various opinions entertained by distinguished anatomists respecting the nerves of the heart; some having maintained that the human heart is copiously supplied with nerves, and others that it has few or none. In September 1846, the author resolved to dissect, under the microscope, the nerves of the heart while covered with alcohol, as he had done those of the uterus. His examinations of the fœtal heart, of the heart of a child at the age of six years, of the heart of an adult in the sound state, of the human heart greatly hypertrophied, and of the heart of the ox, warrant, he thinks, the following conclusions:—1st, that the blood-vessels and the muscular structure of the auricles and ventricles of the heart are furnished with numerous ganglia and plexuses of nerves which have hitherto been neither described nor represented by any anatomist; 2ndly, that these nervous structures of the heart, which are distributed over its surface and

throughout its walls to the lining membrane and *columnæ carneæ*, enlarge with the natural growth of the heart before birth, and during childhood and youth, until the heart has attained its full size in the adult; 3rdly, that when the walls of the auricles and ventricles are affected with hypertrophy, the ganglia and nerves of the heart are enlarged like those of the gravid uterus; and 4thly, that the ganglia and nerves which supply the left auricle and ventricle in the natural state, are more than double the size of the ganglia and nerves distributed to the right side of the heart.

The author observes that the ventricles and auricles of the human heart and of those of the hearts of the larger quadrupeds, are covered with two distinct membranes; the exterior is the serous membrane, connected by cellular tissue with another distinct tunic, which has scarcely, if at all, been noticed by anatomists. This second membrane is stated to have a dense fibrous structure, to be semitransparent, and to resemble in a remarkable manner the aponeurotic expansions, or fasciæ, covering muscles in other parts of the body; and, like them, it sends numerous fibres or processes between the muscular fasciculi, blood-vessels, nerves, and adipose substance of the heart. This membrane, the author thinks, may appropriately be termed the *cardiac fascia*, and he states that, through this, after the removal of the serous membrane, there are numerous ganglia and plexuses of nerves visible to the naked eye. If these nerves be traced backwards towards the base of the ventricles, they are seen to terminate in a great ganglionic plexus, situated between the pulmonary artery and aorta; into which plexus branches of nerves enter from the par vagum of each side, the recurrent and the sympathetic nerves. From this great ganglionic plexus, which the author considers to be the root of all the principal cardiac nerves, branches invested with a soft neurilema proceed to the auricles and ventricles, and their septa. Large flat branches of nerves pass from this ganglionic mass to the coronary arteries, the trunks of which they completely surround like a sheath, and all the ramifications of which they accompany, not only over the surface of the heart, but into the muscular substance, and they are distributed with these arteries throughout its walls to the lining membrane. The author also states that there are besides numerous branches of nerves from the great ganglionic plexuses at the base of the heart and surrounding the coronary arteries, with ganglia distributed over the surfaces of both the ventricles, which do not accompany the blood-vessels, but run obliquely across them, and also across the fibres of the muscular coat. These superficial cardiac nerves are described as being remarkably soft, flat, of a grey colour, and somewhat transparent, as had been formerly stated by Scarpa. Towards the left side and apex of the left ventricle, these nerves lie in grooves or depressions of the muscular coat, and spread out into ganglionic enlargements, from which innumerable filaments are sent off laterally to the muscular coat. There are ganglia of considerable size on these superficial nerves where they are crossing the arteries, which send branches to the coats of the vessels, and some of which branches pass down with the vessels into the substance of the heart.

Reference is made to three drawings intended to accompany the paper, but the first of these drawings only was received with the paper.

June 3, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

The Right Hon. Viscount Morpeth was elected into the Society.

A paper was read, entitled "On a Function of the Red Corpuscles of the Blood, and on the Process of Arterialization." By George Owen Rees, M.D., F.R.S. &c.

The author states that he was first led to the new theory he has formed for the explanation of the chemical phenomena of respiration, and more especially of the change in the colour of the blood which occurs in that process, by having observed that a garlick odour, similar to that evolved from phosphorus, was produced by agitating in distilled water the clot obtained from some specimens of venous blood. His attention was consequently directed to the investigation of the state in which the phosphorus exists in the blood; and the result of that investigation was the theory, of which the following is a succinct outline.

The venous corpuscles are known to contain fat in combination with phosphorus. This compound ingredient of the corpuscles, on coming into contact with atmospheric oxygen during the respiratory act, is consumed, and combining with that oxygen, forms the carbonic acid and water which are expired, and also phosphoric acid, which, uniting with the alkali of the liquor sanguinis, forms a tribasic phosphate of soda. This salt, like many others, acts upon hæmatosine in such a manner as to produce the well-known bright arterial tint.

The analyses which the author has performed in order to test the correctness of this theory were made upon the blood, both of the veins and of the arteries of the same animal; and also upon separated portions of the same venous blood; one of which portions had been artificially arterialized by having been brought into contact with air, while the other portion had not been so exposed. These comparative experiments showed that arterial blood, both when obtained from the vessels and when artificially produced, contains in its serum a larger proportion of tribasic phosphate of soda than that obtained from the veins. The venous corpuscles, as they are contained in the clot, yield a fatty matter combined with phosphorus; while those from arterial blood yield a fat, the ashes of which manifest an alkaline reaction. Thus the venous corpuscles are shown to be acted upon both by respiration and by the artificial arterialization of the blood, in such a manner as to lead to the formation of tribasic phosphate of soda at the expense of the phosphorus they contain.

No exact quantitative analyses were attempted by the author, the comparative experiments having been performed on small portions only of serum (from 25 to 40 grains); sufficiently large, however, to furnish satisfactory evidence of the actual presence of the phosphate in arterial blood, and also in those portions of venous blood which had been arterialized out of the body; while no such indications were obtained from similar portions of the blood contained in the veins.

At the conclusion of the paper, the author notices the experiments of Enderlin, in which no alkaline carbonate could be detected in the ashes of blood; and shows that this is the natural consequence of the phosphates of the clot being oxidized during combustion, and thus supplying a quantity of phosphoric acid sufficient to decompose completely the alkaline carbonate produced by the incineration of the lactate and albuminate of the serum. Most specimens of serum, even as obtained from arterial blood, yield an alkaline carbonate when incinerated; and this is always the case with the serum of venous blood. The author, therefore, thinks himself warranted in regarding the conclusion founded on Enderlin's experiments, that the blood contains no lactate, as being erroneous.

June 17, 1847.

The MARQUIS OF NORTHAMPTON, President, in the Chair.

1. "Electro-Physiological Researches, 5th, 6th, and 7th Series." By Signor Carlo Matteucci, Professor in the University of Pisa. Communicated by Michael Faraday, Esq., D.C.L., F.R.S., &c.

The fifth series of these researches contains the sequel of the author's investigations of *induced contractions*, which, in his third memoir, published in the Philosophical Transactions for 1845, he had considered as being due to nervous influence acting through the muscles during their contraction, and was therefore referable to a kind of nervous induction, and not to the generation of any electric current by muscular contraction. From the experiments related in the present paper, he is led to the conclusion that the phenomena of induced contraction belong exclusively to the muscle in the state of contraction. He now, however, finds reason for doubting that the fact is established that induced contractions are not due to an electric discharge produced during the contraction of the muscle.

The second section of this memoir relates to the phenomena elicited by the passage of the electric current through the nerves of a living animal, or of one recently killed, according to the direction of the current. He finds that in whatever manner the current passing through the nerve of the inverse limb is arrested, tetanic contraction is excited. In order to produce this effect, it is sufficient to moisten the nerve with a large drop of water, or to double it

back upon itself. Phenomena perfectly analogous to those observed in frogs, may be produced in warm-blooded animals, by the action of inverse currents; they continue, however, for a much shorter time, especially if the vitality of the animal is very great. These phenomena clearly belong to the nerve, and have their origin in the relation, the nature of which is yet undetermined, which exists between nervous influence and the action of the electric current according to the direction of that current. Thus a limb traversed by the direct current may be compared to a limb fatigued by repeated efforts; the inverse current may be supposed to act in an opposite manner, and during its passage, the nervous force may accumulate in the nerve. The facts here recorded may establish a fresh connection between nervous influence and the passage of the electric current according to its direction.

The sixth series treats of the laws of the electric discharge of the Torpedo and other electrical fishes, and of the theory of the production of electricity in these animals. Irritations applied to any point of the body of an electrical fish are transmitted by the nerves to the fourth lobe of the brain, and are then followed by the electric discharge: the nervous action by which this discharge is determined under the influence of the will resides in that fourth, or *electrical lobe* of the brain; for after the three superior cerebral lobes have been removed, the torpedo can still give the shock, either voluntarily, or by external irritations. The separation of the two electricities which takes place in the cells of the electrical organ, under nervous influence, are instantaneously reunited by the discharge. The strength of the current obtained during the discharge is proportional to the length of the cellular prisms included in the closed circuit. The author concludes that the nervous force increases independently of the will with every increase in the activity of the functions of circulation and of respiration, and of every act of nutrition, and also under the influence of certain agents introduced into the system.

The seventh and last series treats of the relation that exists between the intensity of the electric current and that of the corresponding physiological effect. A detailed account is given of the apparatus employed, and of the method of experimenting, which the author had recourse to in his researches on this branch of the subject. The amount of the contractions produced in muscles under different circumstances of electric excitation is stated in a table which closes the paper.

2. "On different properties of Solar Radiation, producing or preventing a deposit of Mercury on Silver Plates coated with Iodine, or its compounds with Bromine or Chlorine, modified by coloured glass media and the vapours of the atmosphere." By A. C. Claudet. Communicated by Sir David Brewster, K.H., D.C.L., F.R.S., &c.

At an early period of the study of photography, it was observed that the red, orange and yellow rays are endowed with antagonistic powers, preventing and destroying the action produced by white

light, or by the rays properly called *photogenic rays*. One of the first discoverers of this property was Dr. Draper of New York: his experiments were made with the pure rays of the spectrum acting on the Daguerreotype plate. Previously to this, however, Sir J. Herschel had made similar observations on the action of the pure rays of the spectrum on several kinds of photogenic paper. Dr. Draper also found that the red, orange and yellow rays which protect the plate from ordinary photogenic action, are themselves capable, when isolated, of producing a peculiar photogenic effect. In opposition to the hypothesis of an antagonistic or destroying action exercised by the red, orange and yellow rays, M. E. Becquerel announced that those rays are endowed with the property of continuing the action commenced by the photogenic rays.

The author of the present paper has made a series of observations on light transmitted through certain colouring media, through the vapours of the atmosphere, and through red, orange and yellow glasses. Having directed a camera obscura to the sun when his disc appeared through a fog quite red, he obtained, after ten seconds, a black image of the sun. The red sun had produced no photogenic effect, although the surrounding spaces had been sufficiently affected by the photogenic rays coming from the zenith to attract the white vapour of mercury; thus proving that the red rays have no photogenic power. In another experiment he left the plate in the camera during twenty minutes. The sun had passed over a long space on the surface of the plate, and the result was a long image of the sun, quite black throughout; so that not only the red sun had produced no photogenic action, but the red rays had destroyed the effect produced previous to their passage. Not content with the result obtained by the slow motion of the sun, he next moved the camera obscura from right to left, and *vice versâ*, lowering it each time by means of a screw. In this manner the sun was made to pass rapidly over five or six zones of the plates, and its passage was marked by long black bands, while the intervals were white; showing again that in order to destroy the action of the photogenic rays, it was sufficient to cause the red rays to pass rapidly over the spaces previously affected by the former.

He afterwards operated with coloured glasses. After having taken the impression of a piece of black lace by white light on a Daguerreotype plate, he covered one half of the plate and exposed the other to the radiation of a red glass. The mercury developed an image of the lace on the part which had been acted on only by the white light; and the other part, which had afterwards received the action of the red rays, remained black. The red glass had destroyed the photogenic effect, precisely as was the case with the red light of the sun. He made similar experiments with orange and yellow glass, and obtained analogous results, but in different periods of time. These experiments prove that the red, orange and yellow rays destroy the effect of photogenic light, whether these rays are produced by the prism or by the action of coloured media; but the author believes that he was the first to remark, that after the de-

struction of the photogenic effect, the plate is perfectly restored to its former sensitiveness to white light.

After exposing a plate to the daylight, and then submitting it to the destructive action of red, orange or yellow rays, it will be found to be again sensitive to the same white light. It appears from the author's observations, that a plate may be exposed to these two actions alternately, for any number of times, without altering the final property of the surface, which will be invariably sensitive to the vapours of mercury, if its last exposure has been to the action of white light; whilst it will be deprived of that sensitiveness if it has been exposed lastly to the action of the red, orange or yellow rays. It results from the restoring action of the red, orange and yellow rays, that Daguerreotype plates may be prepared in open daylight; and that in order to give sensitiveness, it is necessary only to place the plate for some minutes under red glass before putting it into the camera obscura. The knowledge of this will be advantageous to persons wishing to take views in places where it is difficult to find dark rooms in which to prepare the plates.

Besides the destructive actions of the red, orange and yellow glasses, these same radiations are endowed with a photogenic action of their own; that is to say, they have, like the blue and violet rays, the power of causing the fixation of mercurial vapours. Those radiations, therefore, are endowed with two actions of a contrary nature; one destructive of the effect of the photogenic light, and the other producing an effect analogous to that light.

The photogenic action of the red rays is 5000 times, that of the orange 500 times, and that of the yellow 100 times slower than white light in producing an equal amount of effect. The destructive action of the red rays is 100 times slower than that of the white light, the orange 50 times, and the yellow only 10 times. When a plate has been exposed to the destructive action of any particular ray, it cannot be affected photogenically by the radiation which has destroyed the first effect; it is sensitive only to the other radiations. The photogenic action of any radiation cannot be continued by another.

The solar spectrum is therefore endowed with three different photogenic actions, and three different destroying actions, corresponding with the red, the yellow and the blue rays. The three photogenic actions of the spectrum thus distinguished have distinct characters; each of these radiations is endowed with a photogenic power peculiar to itself, and which gives to the Daguerreotype plate an affinity for mercurial vapours; nevertheless these three actions are so different, that we cannot, by mixing them artificially, make one assist the other; for they are antagonistic. The effect produced by the blue rays is destroyed by the red and yellow; the red and yellow mutually destroy each other, and the effect of either is destroyed by the blue. The alternate changes of the surface of the plate by these three kinds of radiation seem to prove that the chemical compound remains always the same under these different influences, and that there is no separation or disengagement of the constituent elements.

The author has no doubt that electricity, which accompanies each radiation, acts positively under the influence of the one, and negatively under that of the other, without changing the chemical compound; in the one case this influence would give the affinity for mercury, and in the other it would destroy it.

3. "On the Value of Absolute Alcohol in Spirits of different Specific Gravities." By George Fownes, Esq., F.R.S., Professor of Practical Chemistry in University College, London.

Having been recently engaged in a series of experiments on the fermentation of sugar and molasses, which rendered it necessary to refer to a table of the value in absolute alcohol of spirits of different specific gravities, the author found himself compelled to construct for this purpose a new table, which he lays before the Royal Society in the present paper.

The table was formed by weighing out absolute alcohol and distilled water in fixed proportions, mixing them, and after allowing time for condensation, determining with suitable precautions the specific gravity of each mixture at the temperature of 60° Fahrenheit. Each alternate number in the table was so obtained; the rest being interpolated. The alcohol employed was prepared by digesting the strongest rectified spirit, first with dry carbonate of potash and afterwards with powdered quicklime and distilling. It had the specific gravity ·7938 at 60°, and boiled at 177° Fahr.

The table is followed by a diagram for the purpose of contrasting the actual specific gravities found by experiment with the calculated mean specific gravities of the various mixtures of alcohol and water, in which the specific gravities are indicated by horizontal lines and the proportions of the two liquids by vertical lines. The mean specific gravities of course run straight across the diagram from corner to corner, while the actual specific gravities form an irregular curve with upward convexity, rising rapidly to near its maximum deviation at 30 per cent., proceeding nearly parallel with the other line to 50 per cent., and thence declining until it reaches the extremity of the scale.

4. "On the existence of alternating diurnal Currents of Electricity at the Terrestrial Surface, &c., and their connection with the Diurnal Variation of the Horizontal Magnetic Needle." By W. H. Barlow, Esq., M.I.C.E. Communicated by Peter Barlow, Esq., F.R.S., &c.

The observations recorded in this paper were undertaken in consequence of certain spontaneous deflections having been noticed in the needles of the Electric Telegraph on the Midland Railway. The telegraph is constructed on the principle patented by Messrs. Wheatstone and Cooke, and the signals are made by deflecting a magnetic needle placed in a coil, to the right or left, by means of a galvanic battery. It was observed that when no signals were passing, and when the wires of the telegraph had simply connexion with the earth at the two termini, spontaneous deflections, differing

in amount and direction, occasionally occurred. It was also observed in the four principal lines of telegraph which unite at Derby as a centre, two of which proceed in a northerly direction to Leeds and to Lincoln, and two in a southerly direction to Birmingham and to Rugby, that the relative deflections of the four instruments were such as to indicate that when the current of electricity, which produced the deflection, flowed from Rugby northwards towards Derby, it was also flowing northwards in all the other three; and likewise, that when it flowed southwards in one, it flowed southwards in all; the times of the deflections being simultaneous or nearly so. There appeared to be no regularity as to the hours, either during the day or night, at which these deflections occurred. Atmospheric electricity also affected the instruments, but in general only by sudden and violent effects during thunder storms, sometimes reversing the poles of the needles contained in the coils, and sometimes fusing the wire of the coil itself. But the effects first mentioned appeared to arise from a different cause; and from the great extent of line affected simultaneously by currents in the same direction, it appeared impossible they could arise from local atmospheric influences. On the night of Friday the 19th of March, there appeared a brilliant aurora, and during the whole time of its remaining visible, rapidly alternating deflections were exhibited in the telegraph instruments.

The occurrence of these phenomena induced the author, with deflectometers of very delicate construction, to make a series of experiments, from which the following results were deduced. Wires insulated throughout, and wires having only one connexion with the earth, produced no deflection; and a complete circuit made by uniting both extremities of two wires, each forty-one miles long, but insulated throughout, produced no deflection. In every case, however, a deflection was obtained on a wire having both ends connected with the earth, which deflection was continually varying in amount and sometimes in direction.

On making a series of observations every five minutes for twenty-four hours, at both extremities of a wire, from Derby to Birmingham, it was found that the changes, both of amount and direction, occurred simultaneously at the two ends, and that the current flowed from one end communicating with the earth to the other. The examination of this series of observations showed a general direction of the needle to the right from noon till near midnight, and then to the left until between nine and ten A.M., when it again changed to the right. In consequence of this apparent regularity, the experiments were carefully followed up at Derby for a fortnight on the two telegraphic wires proceeding from Derby to Rugby and Birmingham. These experiments showed that the electric current was subject to a regular diurnal alternation, the times of zero agreeing nearly with the known times of zero of the variation of the magnetic needle; and also that the deflection to the left corresponded with easterly variation, and the deflection to the right with westerly variation; the path described by the needle of the deflectometer

being by no means steady and uniform, but subject to alternating changes of greater or less amount. The effects exhibited on these wires, and which, from the experiments, were found to occur on the north of Derby as well as on the south, would be accounted for by supposing that they were caused by alternating currents of electricity on the earth's surface in a northerly and southerly direction, proceeding towards the north until 9 A.M., and towards the south until from 7 to 12 P.M., and then again turning northwards; agreeing, therefore, nearly in point of time with the usual times of daily change in the direction of the magnetic needle. The experiments, as has been stated, were continued during a fortnight, and the deflection noted every five minutes, day and night. The paper contains the tabular records of these observations; and also diagrams are given exhibiting the daily path of the needle.

The author concludes his paper by expressing his regret that his avocations do not allow him sufficient leisure to prosecute this inquiry, but that he will be happy to place in the hands of any person desirous of pursuing the subject all the tables and results which he has collected.

5. "On the Direction assumed by Plants during their growth." By Professor Macaire, of Geneva. Communicated by P. M. Roget, M.D., Sec. R.S., &c.

This paper is divided into three sections.

The first section contains an account of some observations and experiments made by the author on the phenomena of the curling of the tendrils of the *Tamus communis*. After a description of the tendril, which in this plant is the footstalk of an abortive leaf, the author shows that the contractile power of the organ is excited by contact with any object whatsoever, and even with another part of the same plant; that the curling begins at the point of contact, but continues in both ends of the tendril, either forming knots, if there be something to embrace, or taking the shape of a cork-screw, if there be not. The knots are completed in a few minutes, and exert a considerable degree of pressure. A separation from the plant stops the curling up of the tendril. The curling always takes place in the same direction from the outside inwards. When the tendril is immersed in water, or in a solution of gum, it does not contract; but at the same time it does not lose the faculty of curling up by contact with a solid body. Ammonia, alcohol, or Eau de Cologne have little or no effect. Diluted sulphuric and nitric acids, even the vapours alone of the last, without actual contact, immediately excite in the tendril an energetic contraction. The same thing happens with a solution of corrosive sublimate. On the contrary, prussic acid stops the curling up that had already begun, and renders the tendril incapable of being again excited by the contact of a solid body.

The conclusions which the author comes to on this subject are, that the contractions of tendrils cannot be explained by the hypotheses of Knight and De Candolle of an unequal action of light on

the two sides, for they are too rapid to be the effect of so slow a process; but that they are the result of a vital property residing in the organ, on which the poisons act as they do on the sensitive plant.

The second section relates to the direction of stems towards the light. After having described the nature of the phenomenon, and stated the explanation of it given by De Candolle, namely, the bending of the stem by an accumulation of carbon and the consequent hardening of the side most acted upon by light, the author endeavours to ascertain if the light exercises a real attraction for the green parts of plants. He operated on naturally floating plants, such as the duckweed (*Lemna minor* and *Polyrhina*), and on different species of other plants placed on cork floats. He placed each of them on water in vases which were partly darkened by screens, and he never saw the plants receiving from the light an impulsion which brought the floats away from the spot where they had been placed. When the plants, fully developed, were kept in the dark part of the vase, there sprouted from the neck of the root a new stem, slender and blanched, that ran all along the water so as to reach the diaphragm, and then gave out leaves and grew erect; but the float was never attracted towards the light, although the new stem which the plant had to produce was often three feet and more in length. In the course of these experiments, he had occasion to notice the tendency of roots when developed in the light in water, to take a spiral shape, and found that the white light appears to favour the production of radicular fibrils, while, on the contrary, the blue light opposes it.

In examining the grounds of Dutrochet's theory on the existence in stems of two systems of cells and fibres decreasing in size from the circumference to the centre, and from the centre to the circumference, by which he explains by endosmose the bending of the stem, the author has found that this bending in contrary directions of the two parts of a stem slit longitudinally has nothing to do with light. In cutting the stem in various directions, it always bends outwards by the swelling of the cells and the resistance of the cuticle, and does not bend at all if this last is removed or slit across in two or three places.

To ascertain if the sap could be supposed to travel by endosmose from cell to cell, he placed within one another three endosmose tubes filled with a solution of sugar; the last, or largest, plunging in water. This was the only one in which any endosmose was visible, the difference in density from the others being insufficient to produce it. It is probable that it would be the same for the cells of plants; and some facts have induced him to think that the liquids penetrate chiefly through the intercellular spaces of the vegetable tissue. He has assured himself by experiments that neither heat nor light have any influence in increasing the quantity or the rapidity of endosmose, and he is, consequently, little inclined to admit this phenomenon as exercising the influence sometimes attributed to it in vegetation, and especially in the inclination of stems towards the light.

The third section relates to the direction of the leaves of plants. After having described the appearance and structure of the two surfaces of leaves, and mentioned the known fact of the direction of the superior or varnished surface towards the light, the author reviews the labours of Bonnet and Dutrochet on this subject. As no direct experiments had proved that the direction of leaves is due to the influence of light itself, he begins by showing, first, that the turning over of inverted leaves does not take place regularly in complete obscurity; secondly, that it is possible to induce a leaf to turn itself over by screening its superior surface, and by lighting its inferior one with an inclined mirror; and thirdly, that when both the surfaces of the leaf are illuminated, the leaf takes a globular form so as to protect the inferior surface from the light. He afterwards shows that although in most plants the turning over of inverted leaves takes place through a movement of the footstalk, yet in some of them it is the flat part of the leaf that curls itself over, and that in all the same thing happens when it is the best way of bringing back the superior surface of the leaf towards the light. This is the case, for instance, when the footstalk has been removed, and when the inferior surface is lighted by a mirror and the superior one is screened by a piece of black paper fixed to it. The flat part of the leaf bends its edges and takes a globular form.

The two surfaces of the leaf do not seem to be under the influence of any real attraction towards the light, for when placed in an inverted position on moveable floats, the leaf turns itself over by means of the footstalk, or the curling of the flat part, without creating any motion in the float. The removal of one or many leaflets in a compound leaf, or of part of a single leaf, does not prevent the turning over of the remainder when placed towards the light in an inverted position. By means of coloured glasses, the purity of the light of which had been ascertained by the prism, it has been shown that the leaves turn over best in the blue rays; next in the violet, but not at all in the red.

The author next examines the differences produced in the power of leaves to exhale and decompose carbonic acid, according as the light shines on one or other of their surfaces. In order to measure the exhalation, he placed in a bottle full of water of known weight, a leaf with one of its surfaces darkened and the other exposed to light, changing the surfaces alternately while the experiment lasted. The result of a great many series of experiments has been to show that the loss of water by exhalation in all temperatures and by all weathers is much more considerable during the same time when the inferior surface of the leaf is exposed to light, than when the superior surface is so exposed. This increase explains the rapid withering and subsequent death of inverted leaves which cannot turn themselves over. In coloured glasses the blue rays created the greatest exhalation; next the diffused white light; next the green; the red rays coming last.

On examining, under the same circumstances, the decomposition of carbonic acid, the author first sought in what part of the leaf this

chemical power resided. He found that the green matter did not possess it in itself, that it operated in the cells of the parenchyma, and that the vessels and pores of the cuticle have a useful influence in the phenomenon, so as to increase the quantity of oxygen gas disengaged. When solar light is received on the superior surface of leaves immersed in spring water, the quantity of oxygen gas disengaged is, in the same time and under similar circumstances, two or three times greater than when it is received on the inferior surface. The same difference may be observed in the diffused light, by means of the leaves of *Camellia japonica*, Portugal laurel, and some others which, when kept during some time in the dark in spring water, give out, when brought into the light, bubbles of oxygen gas through the central vessels of the footstalk.

The following is a brief recapitulation of the facts which the author has attempted to prove in this paper:—

1. The theories advanced to explain the curling up of tendrils, do not agree with the experiments made on those of the *Tamus communis*, this phenomenon being the result of a vital irritability acted upon by chemical agents.

2. The direction of the green parts of plants towards the light is not the result of an attraction properly so called.

3. The bending outwards of slit stems is due to the elongation of the cellular tissue by endosmose of water and the resistance of the cuticle.

4. The quantity or rapidity of endosmose is not influenced by heat or light.

5. Light is the only agent of the natural position of leaves and of their turning over when inverted. The blue are the most, the red the least active rays.

6. Light does not act in this case by a physical attraction or repulsion, properly so called.

7. The turning over of leaves takes place sometimes by a torsion of the footstalk, sometimes by a curling of the flat part.

8. The blue rays appear to be the most, and the red the least active in operating the turning over of leaves.

9. The exhalation of leaves is much increased when their inferior surface is exposed to light.

10. The decomposition of carbonic acid and the disengagement of oxygen gas are, under the same circumstances, considerably diminished.

6. "On the Solution of Linear Differential Equations." By Charles James Hargreave, Esq., B.L., F.R.S., Professor of Jurisprudence in University College, London.

1. By the aid of two simple theorems expressing the laws under which the operations of differentiation combine with operations denoted by factors, functions of the independent variable, the author arrives at a principle extensively applicable to the solution of equations, which may be stated as follows:—"if any linear equation $\varphi(x,D).u=X$ have for its solution $u=\psi(x,D).X$, this solution being

so written that the operations included under the function ψ are not performed or suppressed, then $\phi(D,-x).u=X$ has for its solution $u=\psi(D,-x).X$." The solution thus obtained may not be, and often is not, interpretable, at least in finite terms; but if by any transformation a meaning can be attached to this form, it will be found to represent a true result.

An important solution immediately deducible from this principle is given by Mr. Boole in the Philosophical Magazine for February 1847, and is extensively employed in the present paper. It is immediately obtained by making the conversion above proposed in the general equation of the first order and its solution.

2. By the use of this theorem and the general theorems above referred to, the solution of the equation

$$D^2u+2Q.Du+\left(c^2+Q^2+Q'-\frac{m(m+1)}{x^2}\right)u=P,$$

is found in the form

$$u=x^m\varepsilon^{-\int Q dx}(D^2+c^2)^{m-1}\{x^{-1}(D^2+c^2)^{-m}(x^{-(m-1)}.\varepsilon^{\int Q dx}.P)\};$$

of which various particular cases and transformations are given and discussed; including the well-known forms

$$D^2u+\frac{2m}{x}Du\pm c^2.u=P,$$

$$D^2u+bDu+\left(c^2-\frac{m(m-1)}{x^2}\right)u=P,$$

$$\frac{d^2u}{dz^2}+\left(\frac{c}{2n-1}\right)^2 z^{-\frac{4n}{2n\pm1}}.u=0,$$

and extensions of these forms.

The application of the process to equations of the third and higher orders gives rise to solutions of analogous forms; and in particular the equation

$$(a_nx+b_n)D^nu+\ldots+(a_1x+b_1)Du+(a_0x+b_0)u=X$$

is solved in the form

$$u=(a_nD_n+..+a_1D+a_0)^{-1}\varepsilon^{\frac{b_n}{a_n}D}(D-\alpha)^A(D-\beta)^B\ldots$$
$$\left(x^{-1}\left\{\varepsilon^{-\frac{b_n}{a_n}D}(D-\alpha)^{-A}(D-\beta)^{-B}\ldots.X\right\}\right),$$

where $\frac{b_nz^n+b_{n-1}z^{n-1}+\ldots}{a_nz^n+a_{n-1}z^{n-1}+\ldots}=\frac{b_n}{a_n}+\frac{A}{x-\alpha}+\frac{B}{x-\beta}+\ldots$;

and by the application of the theorems first referred to, a still more general form is solved.

The solutions above-mentioned are subject to the important restriction that m, A, B, &c. (denoting the number of times that the

operations are to be repeated) must be integer; but in the subsequent part of the paper, a mode is suggested of instantaneously converting these solutions into definite integrals not affected by the restriction.

3. The interchange of symbols above suggested frequently renders available forms of solution which otherwise would not be interpretable in finite terms. The operation $(\varphi D)^m$ is not intelligible if m be a fraction; but if by any legitimate process this be changed into the factor $(\varphi(-x))^m$, the restriction ceases to operate. By the application of this principle, solutions of a simple character are obtained for (b being integer),

$$(x^2+c^2)D^2u-2axDu+b(2a-b+1)u=P,$$

$$\frac{d^2u}{dt^2}-\frac{b(b+1)}{\cos^2 t}u=P,$$

$$\frac{d^2u}{dt^2}-b(b+2)\frac{1}{(1-t^2)^2}.u=P,$$

$$\varphi x.D^2u+\psi x.Du+(\psi' x-\varphi'' x)u=P.$$

4. The advantages of the forms above given in this particular, that the number and order of the operations in the solution are expressed *generally*, and not by a series of substitutions involving changes of the variable as in the ordinary mode of solving Riccati's equation, appear more clearly in the application to partial linear differential equations. Thus, the equation

$$\frac{d^2u}{dx^2}+\frac{2n}{x}\frac{d^2u}{dxdy}+\left(\frac{n^2}{x^2}-k^2\right)\frac{d^2u}{dy^2}-\frac{n}{x^2}\frac{du}{dy}-\frac{m(m-1)}{x^2}.u=\psi(x,y),$$

which may be solved by m successive substitutions, receives its solution in the general form

$$u=x^m\varepsilon^{-n\log x.D'}(D^2-k^2D'^2)^{m-1}$$
$$\left\{x^{-1}(D^2-k^2D'^2)^{-m}\left\{x^{-(m-1)}\varepsilon^{n\log x D'}\psi(x,y)\right\}\right\};$$

which exhibits at a glance all the successive processes to be performed upon $\psi(x,y)$ in order to arrive at the result. It will be observed that the process $\varepsilon^{\varphi x.D'}$ performed upon ψy denotes $\psi(y+\varphi x)$. Among other results worthy of notice on this branch of the subject may be noticed the solution of

$$\frac{d^2u}{dpdq}+\frac{a}{p+q}\left(\frac{du}{dp}+\frac{du}{dq}\right)+\frac{a(a-1)-m(m-1)}{(p+q)^2}=\varphi(p,q)$$

(solved by Euler in a series when there is no second term); viz.

$$u=x^{m-a}(D^2-D'^2)^{m-1}\left\{x^{-1}(D^2-D'^2)^{-m}\left\{x^{a-m+1}.\psi(x,y)\right\}\right\};$$

ψ being determined from φ by the equations $\frac{p}{q}=x\pm y$; and the solution of

$$(a_nx+b_n)\frac{d^nu}{dx^n}+(a_{n-1}x+b_{n-1})\frac{d^nu}{dx^{n-1}dy}+..+(a_0x+b_0)\frac{d^nu}{dy^n}=\varphi(x,y)$$

which is readily deduced from the solution of the corresponding form in ordinary equations.

5. The character of most of the solutions may be described as follows: they consist in the performance (repeated m times) of operations of the form φD upon the second side X; multiplication by the factor x^{-1}; and the performance (repeated $m-1$ times) of the inverse operation $(\varphi D)^{-1}$; and it will be seen that, in all cases where X=0, it is sufficient to perform the direct operation φD a single time.

It is a remarkable phenomenon connected with the solutions last mentioned, that they are instantaneously convertible into definite integrals by changing φD into φz, multiplying by ϵ^{xz}, changing x^{-1} into D'^{-1} (D' denoting differentiation with regard to z), and assigning proper limits for the integral. In this manner definite integrals are immediately found for

$$D^2u+2Q.Du+\left(Q^2+Q'-c^2-\frac{m(m-1)}{x^2}\right)u=0,$$

$$D^nu+\frac{u}{x}=0,$$

$$D^nu+x.u=0,$$

$$(a_nx+b_n)D^nu+..+(a_0x+b_0)u=0,$$

and other forms.

6. The application of the principle above stated to equations of finite differences gives solutions for the equations

$$(a_nx+b_n)u_{x+n}+....+(a_1x+b_1)u_{x+1}+(a_0x+b_0)u_x=Q_x,$$

$$(a_nx+b_n)\Delta^nu_x+....+(a_1x+b_1)\Delta u_x+(a_0x+b_0)u_x=Q_x;$$

and where the number of operations to be performed is denoted by a fraction, solutions are found in the form of definite integrals.

The solution of the first when $Q_x=0$ is

$$u_x=c_1\int_0^{\alpha}(a_nv^n+..a_1v+a_0)^{-1}v^{b_0}(v-\alpha)^{A_1}(v-\beta)^{A_2}\ldots v^{x-1}dv$$
$$+c_2\int_0^{\beta}(a_nv^n+..a_1v+a_0)^{-1}v^{b_0}(v-\alpha)^{A_1}(v-\beta)^{A_2}\ldots v^{x-1}dv$$
$$+\ \&c.;$$

and that of the second is somewhat similar.

From some investigations effected by interchanging the symbols x and D in the solution of the general linear equation in finite differences of the first order, it would seem that definite summations may be used to represent the solutions of certain forms of equations. Thus a partial solution of

$$z^{-x}.u-\mathrm{D}^n u=c$$

is $c\Sigma(\Gamma z)^n z^{xz}$ from $z=-\infty$ to $z=0$.

7. In attempting the solution of some equations by means of successive operations, not consisting exclusively of D combined with constants, but involving also functions of x, the only result which appeared to the author worthy of notice is the solution of

$$\mathrm{D}^2u+b\mathrm{D}u+c^2u-n(n+1)\frac{u}{\cos^2 x}=\mathrm{X};$$

from a particular case of which, the general solution of Laplace's equation,

$$\frac{d}{d\mu}\left((1-\mu^2)\frac{du}{d\mu}\right)+\frac{1}{1-\mu^2}\frac{d^2u}{dy^2}+n(n+1).u=0,$$

may be found in the simple form

$$u=\varepsilon^{\tan^{-1}(\mu\sqrt{-1})\frac{d}{dy}}\left(\frac{d}{d\mu}\right)^n\left\{(1-\mu^2)^n\varphi\left(y-2\tan^{-1}\mu\sqrt{-1}\right)\right\},$$

with a similar function using $-\sqrt{-1}$ for $\sqrt{-1}$.

7. "Researches on the Function of the Intercostal Muscles and on the Respiratory Movements, with some remarks on Muscular Power, in Man." By John Hutchinson, M.R.C.S. Communicated by Sir Benjamin Brodie, Bart., F.R.S., &c.

The object of this paper is to demonstrate by models and dissections the action of the intercostal muscles.

After premising an account of the views of several eminent physiologists, and in particular those promulgated by Haller, the author shows that they resolve themselves into the general opinion that the scalene or other muscles of the neck fix the first rib, in order to enable the two sets of intercostal muscles to act either separately or conjointly, as inspiratory or expiratory muscles. He then proceeds to state the proofs that the intercostal muscles possess an action which is independent of any other muscle, and also independent of each other, so that any of the twelve ribs may be elevated or depressed by them either separately or conjointly. He demonstrates the nature of this action by means of models, producing oblique tensions between levers representing the ribs, and allowing of rotation on their centres of motion; and he shows that such tension in the direction of the external intercostal muscles, elevates both the levers until the tension ceases, or the position of the bars by proxi-

mity obstruct each other. If the tension be exerted in a contrary direction, as in the internal intercostal muscles, the bars are both depressed. This movement was demonstrated by a model. It was farther shown that two tensions decussating can, according to the position of the fulcra, be made to act as associates or antagonists to each other. Such motions are to be considered with reference to the fulcra, bars with one fulcrum common to each having no such action; and the author accordingly draws the following conclusions:—

1st. All the external intercostal muscles are true inspiratory muscles, elevators of the ribs, and with this act they dilate the intercostal spaces, thus increasing the cavity of the chest.

2nd. The internal intercostal muscles have a double action; the portions situated between the cartilages are associates in action with the external layer, and act as elevators of the cartilages, while the portion between the ribs are depressors, or antagonists of the external layer, and are here true expiratory muscles; with this they decrease the intercostal spaces.

3rd. These muscles can elevate or depress the ribs independently of any other muscle, fixing the first or last rib. Any one lamella, or series of muscles, can, as required, independently perform inspiration or expiration at any one of the twenty-two intercostal spaces.

4th. In inspiration, the intercostal spaces increase, with a shortening of the muscle; and in expiration, they decrease their perpendicular distance, with a shortening of the muscle.

5th. All parallel intercostal muscles, acting with uniform force, concur in the same effect, whether near the fulcrum or more distant from it, and these muscles gain power with their increasing obliquity as well as speed.

In the third part of the paper an account is given of the difference between the external thoracic space and the internal pulmonic space. The respiratory movements are described in health and disease, and it is shown that the chest is rarely enlarged at two places at one and the same time.

In conclusion the author conceives that he has established the following propositions:—

1st. Costal breathing may be distinguished from abdominal by determining which part is first put in motion, and the kind of respiration may be designated according to the name of such part.

2nd. Healthy costal breathing begins with the motion of a superior rib, which is followed by that of the lower ones in succession.

3rd. Ordinary respiration in men is abdominal, in women, costal; extraordinary breathing is the same in both sexes.

4th. Any of the ribs, from the twelfth to the first, may carry on respiration.

5th. Diseased respiration is of various kinds; the movements may be symmetric or not symmetric, costal or abdominal; all or none of the ribs may move; the abdomen may or may not move; the chest

may dilate in all its dimensions at one and the same time; costal and abdominal breathing may alternate with one another; costal motion may be undulating or not; and all these may be combined in one, which the author terms "*hesitating breathing*;" and lastly, the quantity of air breathed is diminished when there exists pulmonary disease.

8. "On the Structure and Development of the Liver." By C. Handfield Jones, M.B., Cantab. Communicated by Sir Benjamin C. Brodie, Bart., F.R.S., &c.

The author gives a detailed description of the structure of the liver in animals belonging to various classes of the animal kingdom. He states that in the Bryozoon, a highly organized polype, it is clearly of the follicular type; and that in the Asterias, the function of the liver is probably shared between the closed appendage of the stomach and the terminal cæca of the large ramifying prolongations of the digestive sac contained in the several rays. Among the Annulosa, the earthworm presents an arrangement of the elements of the hepatic organ, corresponding in simplicity with the general configuration of the body, a single layer of large biliary cells being applied as a kind of coating over the greater part of the intestinal canal. In another member of the same class, the Leech, in which the digestive cavity is much less simple, and presents a number of sacculi on each side, these elements have a very different disposition; and the secreting cells, although some remain isolated, for the most part coalesce to form tubes, having a succession of dilatations and constrictions, and finally uniting and opening into the intestine. In Insects, the usual arrangement is that of long curved filamentary tubes, which wind about the intestine; these, in the meat fly, are sacculated throughout the greater part of their course, till they arrive quite close to the pylorus, where they open; near their origin they appear to consist of separate vesicles, which become gradually fused together, but occasionally they are seen quite separate. The basement membrane of the tubes is strongly marked, and encloses a large quantity of granular matter of a yellowish tinge, with secreting cells; another portion of the liver consists of separate cells lying in a granular blastema, which cells, in a later stage of development, are seen to be included in vesicles or short tubes of homogeneous membrane, often coalescing and exhibiting a more or less manifestly plexiform arrangement; this portion of the liver is regarded by Mr. Newport as really adipose tissue. The author has termed it the *Parenchymatous portion* of the liver, on account of its general appearance and mode of development, though he has not been able to determine whether the tubes always originate from it. Among the Arachnida, the follicular type of arrangement prevails; and the same is the case with the Crustacea, the follicles in these last being distinctly visible to the naked eye. In Mollusca also, we find the follicular arrangement universally to obtain; yet in certain cases the limiting membrane of the follicles cannot be

shown to exist, and the author therefore thinks that its importance is probably not great, but that it serves chiefly to fulfil the mechanical function which its synonym "*basement*" indicates. The quantity of retained secretion in the liver of molluscs seems clearly to imply that the bile in them is not an excrementitious fluid; it is used slowly on account of the imperfect character of the respiration.

In passing from the Invertebrata to the Vertebrate division of the animal kingdom, and beginning with the class of Fishes, a great change is immediately manifest in the form and character of the biliary organ; it is now a gland of solid texture, to which the term *parenchymal* is justly applied. Two portions may be distinguished in it, namely, the secreting parenchyma, consisting of delicate cells, or very often of nuclei, granular and elaborated matters in great part, and the excreting ducts, which, though completely obscured by the surrounding bulky parenchyma, may yet be satisfactorily demonstrated, and traced often to their terminal extremities in the following manner. If a branch of the hepatic duct be taken up in the forceps, it may be dissected out without much difficulty from the surrounding substance, which is very soft and yields readily to gentle manipulation; when a trunk is in this way removed and placed under the microscope, a multitude of minute ramifications are seen adhering to it; among these not a few may be discovered, which do not appear to have suffered injury; some are occasionally seen terminating by distinctly closed extremities; more usually the duct becomes very minute and gradually loses all definite structure, appearing at last like a mere tract of granular matter; in either case there is no communication by continuity with the surrounding parenchyma. Large yellow corpuscles, peculiar cells, and a considerable quantity of free oily matter usually existing in the liver of various fishes, seem generally to indicate a great superiority in the amount of secretory over that of excretory action, and to betoken clearly the feeble intensity of the aërating function.

In Reptiles, there is the same arrangement in the liver, namely, a secreting parenchyma of cells and an apparatus of excretory ducts, which have the same essential characters as those of fishes; but there exists very frequently in the parenchyma remarkable dark corpuscles, which appear to be masses of retained biliary matter, the import of which, in the situation they occupy, is doubtless the same as that of the similar masses existing in fishes.

In Birds, the parenchyma of the liver is remarkably free from oily or retained biliary matters; it often consists almost wholly of free nuclei and granular matter, with scarcely a single perfect cell; the excretory ducts often greatly resemble those of reptiles, sometimes rather those of mammalia; the essential character is, however, always the same, namely, that they terminate without forming any important connexion with the parenchyma.

In Mammalia, the parenchyma of the liver consists usually of perfect cells, which are arranged often in linear series of considerable

length, radiating from the axis of each lobule; these unite at various points with each other, so as to present a more or less decidedly plexiform appearance. Each lobule, as described by Mr. Kiernan, is separated from the adjacent ones by the terminal twigs of the portal vein, and to a greater or less extent by a "fissure," though in most animals the lobules are continuous with each other both above and below the fissure. The elaboration of the secreted product seems to be most completely effected in the cells adjoining the margins of the lobules, which are often seen to contain a larger quantity of biliary matter than those in the interior, and to be apparently in the act of discharging it into the fissure; the margin of the lobule then presents an irregular surface with large globules of the secretion clustering together all over it. The capsule of Glisson surrounding the vessels in the portal canals gives a fibrous investment to those surfaces of the lobules which are towards the canal; but when it has arrived in the fissures, it forms a continuous membrane lining the surfaces of opposite lobules; this membrane is often truly homogeneous, and closely resembles the basement tissue: there appears occasionally to be a delicate epithelium on its free surface; but this, as well as the membrane itself, is often absent, when the margin of the lobules is in that condition which has just been described and which may be termed *active*. The minute branches of the hepatic duct as they approach their termination undergo a remarkable alteration in their structure; they lose their fibrous coat, which blends itself with the membranous expansions of the capsule of Glisson; their basement membrane becomes gradually indistinct, and at last ceases to exist, and the epithelial particles no longer retain their individuality, but appear to be reduced to mere nuclei, set very close together in a faintly granular basis substance. The mode of their termination is not uniformly the same; frequently they present distinctly closed rounded extremities, between one and two thousandths of an inch in diameter; at other times they seem to cease gradually in the midst of fibrous tissue, the nuclei alone being disposed for some little way in such a manner as to convey the idea of a continuation of the duct. These ducts can seldom be discerned in the fissures, but have several times been seen in the "spaces," where several fissures unite; they do not form anything like a plexus between the lobules. From the anatomical relation of the ducts to the parenchyma, and from the circumstance that a distinct vessel conveying a different kind of blood is distributed to the hepatic duct, as soon as the liver assumes the parenchymal form, it seems probable that the mode in which the secreted bile is conveyed out of the organ, is by its permeating the coats of the minute ducts in obedience to an endosmotic attraction, which takes place between the bile in which the ducts may be said to be bathed, and a denser (perhaps mucous) fluid formed in their interior. The large quantity of oily matter frequently existing in a free state in the secreting parenchyma of the liver, which must be regarded as a product of secretory action, seems to suggest the idea, that a certain quantity of the biliary secretion may be directly absorbed into

the blood, and in this manner conveyed away from the organs, just as occurs in the thyroid body, suprarenal capsules, and other glands unprovided with efferent ducts.

With respect to the development of the liver, the author considers the opinion of Reichart to be decidedly the correct one, namely, that its formation commences by a cellular growth from the germinal membrane, independently of any protrusion of the intestinal canal. On the morning of the fifth day, the œsophagus and stomach are clearly discernible, the liver lying between the heart, which is in front, and the stomach which is behind; it is manifestly a parenchymal mass, and its border is quite distinct and separate from the digestive canal; at this period, the vitelline duct is wide, it does not open into the abdominal cavity, but its canal is continued into an anterior and posterior division, which are tubes of homogeneous membrane, filled, like the duct, with opaque oily contents; the anterior one runs forwards, and forms behind the liver a terminal expanded cavity, from which then passes one offset, which, gradually dilating, opens into the stomach; a second, which runs in a direction upwards and backwards, and forms apparently a cæcal prolongation; and a third and fourth, which are of smaller size, arise from the anterior part of the cavity and run to the liver, though they cannot be seen to ramify in its substance; at a somewhat later period, these offsets waste away, excepting the one which is continued into the stomach, and then the mass of the liver is completely free and unconnected with any part of the intestine. As the vitelline duct contracts, the anterior and posterior prolongations of it become fairly continuous and form a loop of intestine, the posterior division being evidently destined to form the cloaca and lower part of the canal. The final development of the hepatic duct takes place about the ninth day by a growth proceeding from the liver itself, and consisting of exactly similar material; this growth extends towards the lower part of the loop of duodenum, which is now distinct, and appears to blend with the coats of the intestine; around it, at its lower part, the structure of the pancreas is seen to be in process of formation. The further progress of development of the hepatic duct will, the author thinks, require to be carefully examined, but the details he has given in this paper have satisfied him of the correctness of the statement that the structure of the liver is essentially parenchymal.